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HOSPITAL TECHNICAL MEMORANDUM

PNEUMATIC TUBE COMMUNICATION SYSTEMS

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Pneumatic Tube Communication Systems

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I. Introduction

1. Many hospital authorities are interested in the use of pneumatic tube communication systems, particularly in the building of new hospitals, as a means of promoting efficiency and reducing the amount of time spent in running errands between wards, departments and offices.

2. Pneumatic tube communication systems are not new. Their use in department stores to transmit bills and cash between sales positions and a central cashier's office is well known. In hospitals in the United States, where notes of the charges due are often made more or less as treatments to patients are given, pneumatic tubes are used for very much the same purpose. They are also used for the transmission of messages, drugs, pathological specimens, x-ray films and medical records, and it is this latter use, representing a relatively minor part of the tube traffic in the United States hospitals, which is of interest to hospital authorities in this country.

3. The main advantages claimed for pneumatic tubes are that they:

(i) promote a general air of efficiency;
(ii) complete errands more quickly;
(iii) save staff time by reducing errands.

On the other hand, they are said to be noisy; inflexible, in that the location of sending/receiving stations cannot easily be moved to match changes in the use of accommodation; and expensive by comparison with alternative methods of communication.

4. The Ministry's Central O. & M. Unit has made a general examination of the value of pneumatic tube systems in the work of National Health Service hospitals including detailed studies of pneumatic tube systems in this country. This report describes the results of these studies.

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II. Appearance of efficiency

5. The use of modern methods of communication and mechanisation conveys an impression of modernity and efficiency which can be of great value in stimulating pride in a hospital's achievements and in encouraging staff to feel that they are members of a thoroughly up-to-date organisation.

6. So far as this can be justified by results this is an attitude of mind which needs to be encouraged but it will be defeated if the equipment is patently not used to its full capacity or if the staff come to feel that they could do better without it.

7. There is no doubt that the use of pneumatic tube equipment introduces a feeling of efficiency and most ward sisters using tube systems are enthusiastic about their value. In all cases however, this enthusiasm is related to the saving of the time of ward staff which is obtained by the use of this system and not by comparison with the results which can be obtained by the use of other methods of which the ward staff may have had no experience.

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III. Operational considerations

8. The three main types of tube communication systems and the tube sizes are set out in the Appendix. The one most commonly preferred for hospitals incorporates a pre-selector device, and uses 4 inch or $4\frac{1}{2}$ inch diameter steel or plastic tubing which interconnects all sending and receiving stations. It is usual to describe the size of a system by the diameter of the tubing but the diameter of carriers is appreciably smaller than the tube diameter in order to allow them to negotiate bends ; for this reason also there is a limit to the length of carriers. In the 4 inch system the usual internal dimensions of carriers are $12\frac{3}{8}$ inches in length and $2\frac{7}{8}$ inches in diameter. Carriers are propelled through the tube by compressed air or vacuum from any one station to any other, the destination of each carrier being determined by pre-setting a coding device incorporated in the carrier.

9. 4 and $4\frac{1}{2}$ inch diameter tubes are the largest at present available with fully automatic destination pre-selection ; a $5\frac{1}{2}$ inch system is in course of development. Any increase in the internal dimensions of carriers will have only a marginal effect on the total volume of items carried in a hospital, because the increase in size does not widen significantly the range of items which can be carried. A larger tube will increase capital expenditure and running costs.

10. Training of staff in the use of a pneumatic tube system is essential, otherwise misuse is likely to cause breakdowns, often of long duration, which are costly to rectify and may cause considerable inconvenience. This risk is aggravated by the large turn-over of staff in most hospitals.

11. If the intended destination of a carrier is wrongly dialled it will arrive at the wrong destination or at a "reject" station. This reject station must be manned while the system is running so that carriers can be re-directed without delay.

12. To provide evidence that all carriers have reached their correct destination and have been attended to, the operating procedure has to provide for the immediate return of empty carriers to the sending stations. If the carrier is not returned in a reasonable time enquiry has to be made as to its whereabouts. The procedure has to ensure that carriers are available at all stations when needed, and must avoid the use of too many carriers because they each cost over £20.

13. Noise is sometimes said to be a disadvantage of tubes systems. The main objection appears to arise not from the thump of arriving carriers but from the sound of carriers rushing through the tube in places where the tube is not adequately sound-proofed. There has been little complaint in this respect from hospitals in this country, possibly because of the attention given to the siting of the stations and to sound-proofing.

14. One way of reducing the noise of carriers passing through the tube is to use plastic tubing. Exposed plastic tubing has the disadvantage that static electricity causes dust to stick to the tubing, thus creating a cleaning problem. Some concern is being expressed that static electricity might also affect delicate electronic equipment but no evidence is available that this has occurred.

15. When liquids are sent via the tube system it is usual to pack the bottle, etc. surrounded by foam plastic or cotton wool, into a special plastic container which is then placed in the carrier, the object being to prevent breakage or, if leakage occurs, to limit the contamination to the plastic container. Because of failure to pack the carrier properly, breakages and leakages into the main system do sometimes occur. When infectious specimens leak it is usual to sterilise the inner container and the carrier concerned. It has not yet been established whether the system as a whole needs to be sterilised but, in any event, it has not yet been possible to devise a procedure for doing this.

16. The siting of stations has to be carefully planned because it is difficult and costly to change them subsequently. In one hospital studied, five stations were wrongly located.

IV. Traffic transportable by pneumatic tubes

17. Of the very wide range of equipment, goods, materials and communication which need to be moved about a hospital, only a small proportion of the total number, and an even smaller proportion of their total weight or volume, can be sent by tube because of various limitations.

18. For example:

(i) *X-ray films.*

The majority of films are too large to be conveyed by the usual sizes of tube, but apart form this some radiologists object to the rolling of films; in their opinion this is liable to damage the surface of the film and prevent it lying flat against viewing screens for accurate reading.

(ii) *Liquids.*

Although special leak-proof inner containers are available for transmitting liquids by pneumatic tube (e.g. pathological specimens and drugs) breakages and leaks into the main tube, with consequent contamination, can occur. This has led to reluctance to send liquids, particularly infectious ones, by tube. It is significant that many American hospitals with longer experience of tube systems, do not send liquids, particularly those which are infectious, by tube.

(iii) *Blood samples.*

Such samples sent to the pathology laboratory by tube have, on occasions, been found to be centrifuged on arrival. The occurrences have been infrequent and to no set pattern, and the cause has not yet been established. It is possible that it may be due to improper packing of the samples in the carrier by the sending departments. Even though infrequent, these accidents result in some misgivings and further research into the cause needs to be undertaken.

(iv) *Dangerous and scheduled drugs.*

Although lockable containers are available for sending dangerous and scheduled drugs via the pneumatic tube, pharmacists seem to be loth to use them, the greater security of personal delivery with signature discharges at all stages being preferred. The issue of dangerous and scheduled drugs accounts for a high proportion of the errands beween wards and dispensary, and an understandable reluctance to send these by the tube system greatly reduces its potential value in this field. The main objection to the use of tubes for dangerous drugs is similar to the objection in American hospitals to the use of tubes to transmit cash. The risk of wrong destination coding is such that there can be no guarantee that all carriers will reach their prescribed destinations.

(v) *Medical records.*

The biggest traffic of patients' records is between the medical records department and out-patient clinics. Records required for clinics are almost invariably collected together before the clinic is held and taken in bulk to the clinic, and returned in bulk at the end of the session. To send the records by tube one or two at a time would require as many as twenty or more separate dispatches which, allowing only one minute for each of these and the return of the empty carrier, would take longer and involve more staff time at each end than is necessary for delivering them, in bulk, by hand. Some of the larger records could not, in any case, be inserted in a carrier and would have to be taken by hand. At one hospital using a tube system the medical records are kept in stiff covers which cannot be rolled and therefore no medical records are sent via the tube. For these reasons, in a new hospital on the continent, although a pneumatic tube system has been installed, a separate mechanical hoist has been provided to convey records to the out-patient department. There is as yet insufficient experience to show the effect on the folders of sending them by tube, but there are signs that constant rolling causes them to disintegrate.

19. A tube system can convey administrative paper work quickly but the volume of such items as bed statistics, diet sheets, works requisitions, stores requisitions, etc., arising from each ward in a hospital is not great. Many of the requisition forms are submitted at infrequent intervals. Many errands entail not only sending a requisition but also bringing back urgently required stores or equipment. If such requisitions were sent by tube, the return journeys would still be necessary.

20. Assessment of traffic needs by departmental heads is usually based on opinion. This often suggests that errands are far more numerous and urgent than they really are.

21. Actual measurement of errands undertaken by ward staff at five hospitals showed that the number of errands per bed per week was as high as three to four in hospitals where little or no help was given in the form of routine rounds by porters; and as low as one to two in hospitals where there are routine rounds, in particular, by pathology laboratory and dispensary porters. This demonstrates the substantial effect on the number of errands by ward staff of even a small measure of help by porters.

22. Measurement of the effect of tube systems on errands was made at two hospitals: the first was in a tall building, with fourteen wards connected by tube to a few departments including the pathology laboratory, dispensary, x-ray, medical records, casualty, C.S.S.D. and theatres, but not to the administrative offices; the second was a hospital of mainly single storey construction, where four wards were connected by a comprehensive tube system to the administrative offices as well as to the medical departments. The studies showed that in the first hospital the installation of the tube system had eliminated 228 out of a weekly total of 524 errands by ward staff, and in the second hospital the elemination of 867 out of 2,040 errands by the staff of the wards and departments. This amounted to a reduction of 43 to 44 per cent. of errands in each instance (although it should be noted that other studies showed that the use of messengers could achieve an even greater reduction in the number of errands by staff, as is described later in paragraph 35). The similarity in the reduction in both cases suggests that the proportion of errands which can be eliminated is little affected by the layout of the buildings or the numbers and types of departments served by the tube system.

V. Urgency

23. The general tendency in hospitals is to regard all errands affecting the treatment of patients as urgent and to arrange for each one singly as it arises. This results in a large number of single purpose errands, in particular, to the pathology laboratory, the dispensary and the x-ray department. These receiving departments, except in emergencies, treat them all as routine and take each one in turn. The inherent danger is that unless specially earmarked, a really urgent case will not receive the priority it requires.

24. The degree of urgency for the generality of cases is seldom as great as is often imagined. For example, many drugs are given at three or four hourly intervals at set times throughout the day and there is little point in running to the dispensary to obtain urgently a drug which is not required for another two or three hours. Similarly most pathology laboratories, particularly those using auto-analysers, sort their work into batches requiring the same or similar tests and there is little point in rushing a sample to the pathology laboratory if the next run of the particular test required will not be started for another two or three hours.

25. The studies have shown that urgent errands were necessary in some instances only because it was discovered just before a meal that there was a shortage of some essential item of provisions; or just before a medicine round, that the stock of a necessary drug had run out. Errands of this nature are, however, seldom necessary in wards where the standard of management is reasonably good. In general, the normal requirements in a hospital seldom demand that errands should be completed in great haste.

VI. Speed of service

26. The speed of carriers through pneumatic tube systems is 25 to 30 feet per second or 500 to 600 yards per minute. By walking at a normal pace of 3½ miles per hour just over 100 yards is covered in one minute. Apparently, therefore, the tube is at least five times quicker than a messenger in completing an errand. In practice, however, carriers do not necessarily proceed direct from point to point but may follow circuitous routes determined for them by the "selector and spacer mechanisms". In one hospital tests disclosed that over a distance which could be covered on foot comfortably in four minutes carriers sent by tube took two to three minutes.

27. Apart from the actual travelling speed, it is easier and takes less time in emergencies to send a messenger than to pick up a carrier, carefully pack and insert whatever is to be carried, close the carrier, accurately dial and check the code and despatch it. In emergencies, when staff are likely to be under stress, the possibility of incorrectly dialling the appropriate code increases, and with it the danger that the carrier will not reach its appropriate destination in the shortest possible time.

28. Even if a carrier containing something really urgent reaches its appropriate destination quickly, there is no guarantee that it will receive urgent attention unless arrangements exist to ensure all sending/receiving stations are manned at all times. In practice even if such arrangements normally exist carriers are quite often left minutes or even hours before they receive attention. A messenger sent with something urgent, can more reliably ensure that the item reaches the hands of the individual for whom it is intended.

29. The bulk, if not all, of the really urgent items pass between wards, theatres, casualty, the pathology laboratory, the dispensary and the x-ray department. The wards and casualty department function 24 hours per day, but the other departments do not. Because so many departments in a hospital function only during the day it is common practice in the U.S.A. and is likely to become so in this country, that tube systems are switched off at night. It is probable that tube systems will also be switched off at week-ends because the traffic which they can usefully carry at these times is limited.

30. These limitations on the extent to which a tube system can provide a speedy service at all times must be borne in mind in assessing the value of a tube system. During the times when a tube system is not operating an alternative system of communication must be provided.

VII. Alternatives to pneumatic tube systems

31. The alternatives to pneumatic tube systems are the continuance of special journeys which waste staff time or the organisation of an adequate messenger and portering service. Other alternatives might be the use of facsimile transmission systems, which are limited to sending written or printed messages from one point to another, or other electronic systems which have similar limitations. It is to be noted that a messenger service is capable of conveying items which, by weight or volume, cannot be moved by tube.

32. Some hospital authorities have been disappointed with their experiments with messenger services. A satisfactory messenger service requires careful organisation and supervision, and failures are generally due to inadequate organisation.

33. The service should collect from wards at the times which meet their requirements and, at the same time, deliver to departments at times which fit in with their routines. It is essential, therefore, that this information should be ascertained at the outset to ensure that all reasonable demands are met.

34. When all requirements have been ascertained a timetable needs to be devised fixing times for collections and deliveries. Copies of the timetable should be displayed at all calling points. The success of the service will be dependent upon the reliability of the messenger to meet these times, because ward sisters and departmental heads will plan their work accordingly. If the times are not strictly observed, the service will fall into disrepute and the numbers of errands undertaken by ward and other staff will increase.

35. In one of the two hospitals studied the introduction of a messenger service resulted in errands by ward staff being reduced by 66 per cent. In hospitals where the number of errands undertaken by ward staff is less than two per bed per week because of routine rounds being made by departmental porters, the impact of a comprehensive messenger service would be less dramatic.

36. Errands by ward staff cause undesirable interruptions in ward work, but sending an item by tube involves the ward staff in packing a carrier, dialling the code and inserting the carrier in the system. This is a longer process than placing the item in a tray for collection by a messenger. With the tube system a second interruption occurs when the empty carrier is returned because it must be checked to ensure that is in fact empty.

37. One of the prime objects of tube systems is to save ward staff time, particularly nursing time, spent on errands. At the two hospitals with tube systems which have been studied, the savings of ward staff time were about 30 minutes and 50 minutes per ward per day respectively. Of these totals, in each case about 20 minutes represented nursing time, which amounts to a saving of less than 5 minutes per ward nurse per day. The savings of time attributable to a messenger service are only fractionally greater, but the time taken in operating the tube system as described in the preceding paragraph, is avoided.

38. Most ward sisters using tube systems are enthusiastic about their value ; their enthusiasm is, however, no greater than that of their colleagues who rely on efficient messenger services. In medical service departments there is less enthusiasm for tubes than for a messenger service. The arrival of many carriers throughout the working day in, say, the pathology laboratory or dispensary considerably interrupts the work of technical or clerical staff. A messenger service makes relatively few regular calls per day and this not only causes less interruption but the receiving departments can organise their work better because their work arrives in larger instalments and not in piecemeal fashion.

39. The portering establishment of a hospital is largely determined by the extent to which patients, stores, meals, equipment, refuse, etc., have to be moved. Pneumatic tubes make little or no impact on this work and consequently save little or no portering time. Even apparent savings of portering time seldom turn out to be real. For example, patients' letters can be distributed by tube but porters still have to do mail rounds to deliver parcels ; patients' case papers can be sent by the casualty department to wards but porters still have to carry or escort the patient and, therefore, could just as easily also carry the case notes.

40. Comment is made earlier in this paper about the appearance of efficiency which the use of pneumatic tubes conveys. This is valuable, but it needs to be judged in relation to the cost of the installation. If it could be shown that the use of tube systems is economical, this might well outweigh some of the disadvantages which have been described earlier. The costs of tube systems and a messenger service are compared in the following paragraphs.

VIII. The cost of the system

Capital costs of pneumatic tubes

41. The two tube systems described at paragraph 22 cost about £21,800 and £22,000 to serve 26 and 23 sending/receiving stations respectively. The cost per station, therefore, falls within the range of £840 to £960. In each case the systems were installed, in the main, in new buildings. The costs of installing tube systems in existing buildings is likely to be higher.

Revenue costs of pneumatic tubes

42. The annual operating costs of the two tube systems referred to above are:

	Hospital "A" £	*Hospital "B"* £
Amortisation of capital costs over 20 years	1,090	1,100
Interest at 5½ per cent on 50 per cent of capital cost	600	605
Fuel costs (electricity charges)	*990	†730
Maintenance costs	300	360
TOTALS	2,980	2,795

* Running 24 hours per day 7 days per week.

† Running 24 hours per day 5 days per week and 13 hours per day on Saturday.

The annual cost per station is therefore about £118 per annum.

Capital costs of a messenger service

43. Comparatively, the capital cost of setting up a messenger service to serve over twenty collection/delivery points at another hospital was only about £80 ; including the cost of one compartmentalised sorting trolley and the provision and fixing of "in" and "out" Trays at each collection and delivery point. The capital cost per collection/delivery point was therefore, in this case less than £4.

Revenue costs of a messenger service

44. The annual operating costs of the messenger service referred to in paragraph 43 above are:

	Hosp. "C" £
Gross salary (including overtime) of one messenger	627
Relief provision for annual and sick leave	52
Extra help from portering staff on first round of each day	21
	700

This amounts to about £35 per collection/delivery point.

45. The hospital is, however, exploring the possibility of increasing the use of the messenger service.

If, as may prove to be possible, the use of the messenger service can be increased to an extent which will save the time of one porter this would offset almost the entire cost of the messenger service.

Comparison between tube systems and messenger services

46. The running costs, at £700 per annum, of the messenger service described above are approximately one-quarter of those of a tube system to serve approximately the same number of sending/receiving points. Switching off the tube systems between 6 p.m. and 8 a.m. on week-days, and over week-ends from 1 p.m. on Saturday (see paragraph 29) would achieve savings of about £700 and £500 per annum for Hospitals "A" and "B", respectively. Even then the cost of the messenger service would be less than one-third of the tube systems and it would be 50 per cent. more effective in eliminating errands (see paragraph 35).

47. No actual financial savings have been achieved as a result of installing two pneumatic tube installations described in this paper. It could be argued, however, that their cost might be offset by the extent to which they made the staff time available for other work. The cost of the tube service in relation to staff time saved—is at Hospital "A" about £1. 13s. 6d. for each hour of staff time saved. At Hospital "B" the figures are 15s. 9d. for each hour of staff time saved.

48. Expressed in similar terms the cost of a messenger service at Hospital "C" is at present 2s. 2d. for each hour of staff time saved, and if the service is extended as described in paragraph 45 above would amount to only a few pence per hour of staff time saved.

IX. Conclusion

49. In the U.S.A. a prime purpose of the tube system is to carry charge chits from wards and departments to a central accounting office immediately a charge is incurred, in order to facilitate accounting arrangements and to ensure that all items are promptly included in accounts rendered to patients on discharge. In a large American hospital half a million charge chits per year is common. In a large National Health hospital the total volume of tube traffic from all sources is not likely to be more than one hundred thousand items per year. The transmission of messages, etc., is, therefore, five or six times greater in the United States than in this country.

50. A number of pneumatic tubes systems are operating in European hospitals. At the Eleventh International Hospital Congress, Edinburgh, 1959, the view was expressed by the Netherlands that tube systems were advisable only where a large number of messages had to be handled and where speed was of outstanding importance. It was suggested that such systems might be useful between widely separated sections of administrative departments but otherwise the organisation of a transport service was to be preferred. The balance of opinion at the Congress was that pneumatic tube systems in hospitals were open to question. It is significant that one of the largest and newest hospitals in the Netherlands has decided not to install a pneumatic tube system. There are a number of installations in Sweden but there is no evidence that these are more economical or efficient than alternative arrangements.

51. The evidence collected from the studies carried out by the Ministry's Central O. & M. Unit points to the conclusion that in National Health Service hospitals comprehensive pneumatic tube systems are of doubtful value. Their use is limited; their virtue of speed is over-rated; they are expensive to install. By comparison, a well organised messenger service is 50 per cent. more effective in eliminating errands; costs virtually nothing to install and operates at about a third of the cost.

52. While the value of a comprehensive pneumatic tube system compares unfavourably with an efficient messenger service it is possible that point to point communication by tube system may be justified in special circumstances. Separate studies of this possibility are being made by the Ministry's Central O. & M. Unit.

APPENDIX

Sizes and types of pneumatic tube communication systems

Dimensions of tube	*Type A* *One or two direct tubes from each station to a central manual sorting point*	*Type B* *One or two tubes to each station. Destination of carriers determined by setting switches similar to railway points*	*Type C* *Pre-selector system using pre-set code device on carriers*
Standard sizes			
1″ diameter	Available		
1½″ ,, ...	Available		
2¼″ ,, ...	Available	Available	Available
2⅞″ ,, ...			Available
3″ ,, ...	Available	Available	Available
4″ ,, ...	Available	Available	Available
4½″ ,, ...			Available
5½″ ,, ...	Available	Available	
7″ × 4″ rectangular	Available	Available	
12″ × 4″ ,, ...	Available	Available	
13″ × 5″ ,, ...	Available	Available	
Special sizes			
8″ × 5″ rectangular	Available		
2¾″ × ⅜″ ,, ...	Available		
Obsolete			
2″ diameter	Available		

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